



Coastal Engineering Technical Note



OVERFILL AND RENOURISHMENT FACTORS

BACKGROUND AND PURPOSE: The overfill and renourishment factors were devised to estimate relative performance of borrow materials with respect to the native beach materials, both during initial beach stabilization and over the long term. Thus, they help in choosing the best available borrow material. The factors also are used to calculate fill construction volume and renourishment volumes. This note is to clarify definitions and uses of the adjusted SPM overfill factor, R_A , and James renourishment factor, R_J , for beach restoration projects.

DEFINITIONS: Based on the grain size distribution of both native and borrow materials, the adjusted SPM overfill factor, R_A , estimates how much fill will be lost during initial beach stabilization. The value is calculated by assuming that a portion of the borrow material's grain size distribution, which is similar to the native material, is stable, while the finer grains are transported away during initial exposure to waves. R_A is primarily a volume factor which may be used to calculate an intentional overfill to compensate for volume loss.

Using the same grain size data, James's renourishment factor, R_J , estimates long term relative erosion rates of borrow materials with respect to native materials. This is done by assuming all grains have a finite residence time in the local littoral system before being transported offshore or alongshore. Larger grains remain longer. R_J is primarily a rate factor providing a measure of relative long-term stability.

APPLICATION OF R_A AND R_J FACTORS:

1. BORROW SELECTION

The adjusted SPM fill and James's renourishment factors are used for:

R_A : Determining which alternative borrow material will provide the lowest placement volume.

R_J : Determining which alternative will be most stable over time.

R_J values greater than one predict the borrow material will erode at a higher rate than the native beach. Conversely, values of less than one predict the borrow material is more stable. A value of R_J equal to one predicts a similar long term erosion rate.

2. BEACH FILL CONSTRUCTION

A. Overfill volume = $R_A \times$ Design Volume.

Where: Design Volume = the volume contained in the final project dimensions, which is an amount that does not take into account material lost due to initial wave sorting.

B. An additional adjustment is suggested by Equation (5-4) of the SPM (1984) and Hobson (1977) to compensate for silt content of the borrow material.

$$R_G = R_A \times \frac{100}{\% \text{ Sand}}$$

Where: R_G is the modified overfill factor.

This modification is usually quite conservative. The unmodified overfill factor, R_A , already accounts for losses in the fine tail of the grain size distribution. Thus, this further adjustment is unnecessary.

C. When Advance nourishment (Additional Fill to compensate for long-term erosion losses) is to be included, the Renourishment Volume formula (See 3A) is used to calculate additional fill needed.

Total Placement Volume = Advance Renourishment + Overfill Volume

3. RENOURISHMENT

A. Renourishment Volume = $R_J \times$ Native Volumetric Erosion Rate \times Time

Where: Time = Desired Time between Renourishment efforts

B. An alternative to using R_J and Native Erosion Rate is to establish the actual erosion rate of the fill material after it has been placed and gone through initial stabilization. This rate would

then be used in the formula above to replace a Native Erosion Rate. R_J would relate expected renourishment material erosion rate to performance of initial fill material.

- C. Though the same borrow site may be available for a renourishment project, characteristics of the material should be reevaluated. Often finer grained material fills excavation left by previous borrow activities. If, however, the material remaining in the borrow area is identical to that used in the initial nourishment, R_J would be 1.0 and erosion of renourished beach should precede at rates similar to that of initial fill.

EQUATIONS: Figure 5-3 and 5-4 of the Shore Protection Manual (SPM, 1984) can be used to estimate the value of R_A and R_J , respectively. The following equations by James (1974, 1975) should be used for more accurate computations of R_A and R_J . Equations for numerical computations are presented below:

The Overfill Factor, R_A , is given by:

$$\frac{1}{R_A} = 1 - \operatorname{erf}\left(\frac{\theta_2 - \delta}{\sigma}\right) + \operatorname{erf}\left(\frac{\theta_1 - \delta}{\sigma}\right) + \left[\frac{\operatorname{erf}(\theta_2) - \operatorname{erf}(\theta_1)}{\sigma}\right] \exp\left\{\frac{1}{2} \left[\theta_1^2 - \left(\frac{\theta_1 - \delta}{\sigma}\right)^2\right]\right\}$$

When $\sigma > 1$: $\theta_1 = \text{Maximum of } \left\{-1 \text{ or } \frac{-\delta}{\sigma_2 - 1}\right\}$; $\theta_2 = \infty$

When $\sigma < 1$: $\theta_1 = -1$; $\theta_2 = \text{Maximum of } \left\{-1 \text{ or } 1 + \frac{2\delta}{1 - \sigma^2}\right\}$

erf = error function

$$\text{When } x \geq 0, \operatorname{erf}(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x e^{-t^2/2} dt$$

When $x < 0$, $\operatorname{erf}(x)$ is replaced by $1 - \operatorname{erf}(x)$

The Renourishment Factor, R_J , is given by:

$$R_J = \exp \left[\Delta \left(\frac{\mu_b - \mu_n}{\sigma_n} \right) - \frac{\Delta^2}{2} \left(\frac{\sigma_b^2}{\sigma_n^2} - 1 \right) \right]$$

$$\exp(x) = e^x$$

Δ = a dimensionless parameter called the winnowing function which is assumed to be 1 (James, 1974).

Where:

$$\delta = \text{Phi mean difference} = \mu_b - \mu_n / \sigma_n$$

μ_b = Phi mean of borrow material

μ_n = Phi mean of native material

$$\sigma = \text{Phi Sorting Ratio} = \sigma_b / \sigma_n$$

σ_b = Phi standard deviation of borrow material

σ_n = Phi standard deviation of native material

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